U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

2021 PROJECT PEER REVIEW

U.S. DEPARTMENT OF ENERGY
WIND ENERGY TECHNOLOGIES OFFICE

Natural Resources Canada | Ressources naturelles Canada

Canada

E03 - North American Renewable Integration Study

Mitigate Market Barriers – Grid Integration

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August 3, 2021

FY21 Peer Review - Project Overview

Project Summary:

- The North American Renewable Integration Study (NARIS) analyzed the challenges and opportunities of transitioning to a modern electric power system in North America through the year 2050.
- NARIS studied timescales from multiple decades down to minutes and produced novel data sets, methods, and tools for stakeholders and future use.
- Reports done in coordination with the U.S. Department of Energy and Natural Resources Canada.

Project Start Year: [2016]
Expected Completion Year: FY [2021]
Total expected duration: [5] years

FY19 - FY20 Budget: $571,699

Key Project Personnel: Greg Brinkman, NREL

Key DOE Personnel: Jian Fu

Project Objective(s) 2019-2020:

- How reliable and affordable will the grid be in a variety of future scenarios?
- What operating practices (e.g., regional cooperation) and technologies (e.g., storage, demand response) are most important to reliable and affordable operation?
- Are these solutions robust to a wide variety of scenarios and meteorological conditions?
- What is the benefit of interregional and international cooperation in planning and operations?

Overall Project Objectives (life of project):

- Develop new, open-source methods, models, and tools for future study

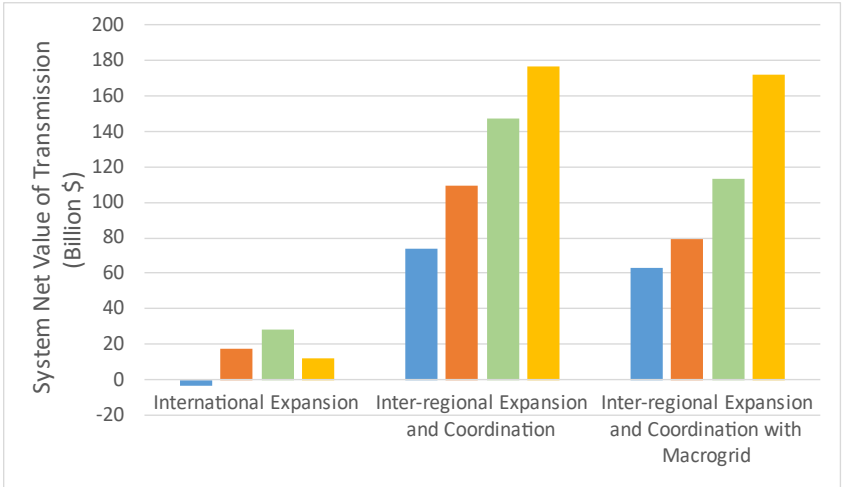
Project Impact

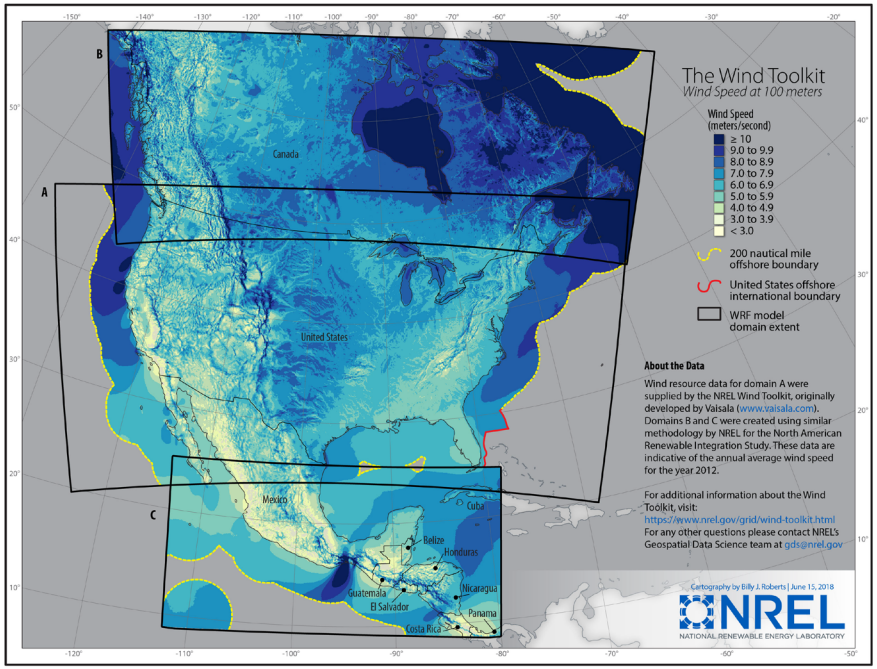
Informing stakeholders on key issues:

- A future low-carbon grid can maintain system adequacy at reasonable cost
- Benefits of transmission and international collaboration in the future grid could be hundreds of billions of dollars
- Wind has a major role to play in this future

New open-source tools and data:

- Results of the modeling for over 40 scenarios
- 5-minute wind resource data (including Canada and Mexico) on Amazon S3
- Open-source resource adequacy tool
- Potential open-sourcing of ReEDS continental model





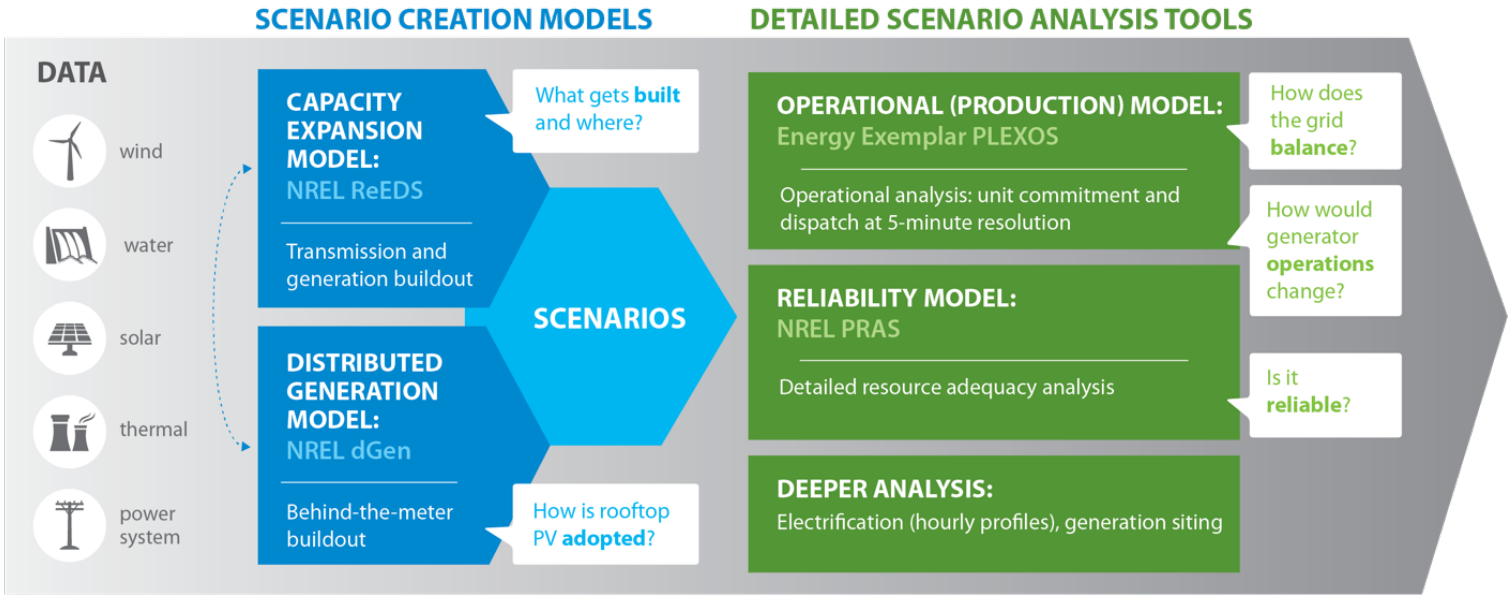
Program Performance – Scope, Schedule, Execution

Timeline:

- International challenges: project timeline was updated during the project (prior to each fiscal year) due to unforeseen changes with project partners
- All WETO milestone and deliverables were completed on time
- Changes to overall NARIS budget and scope

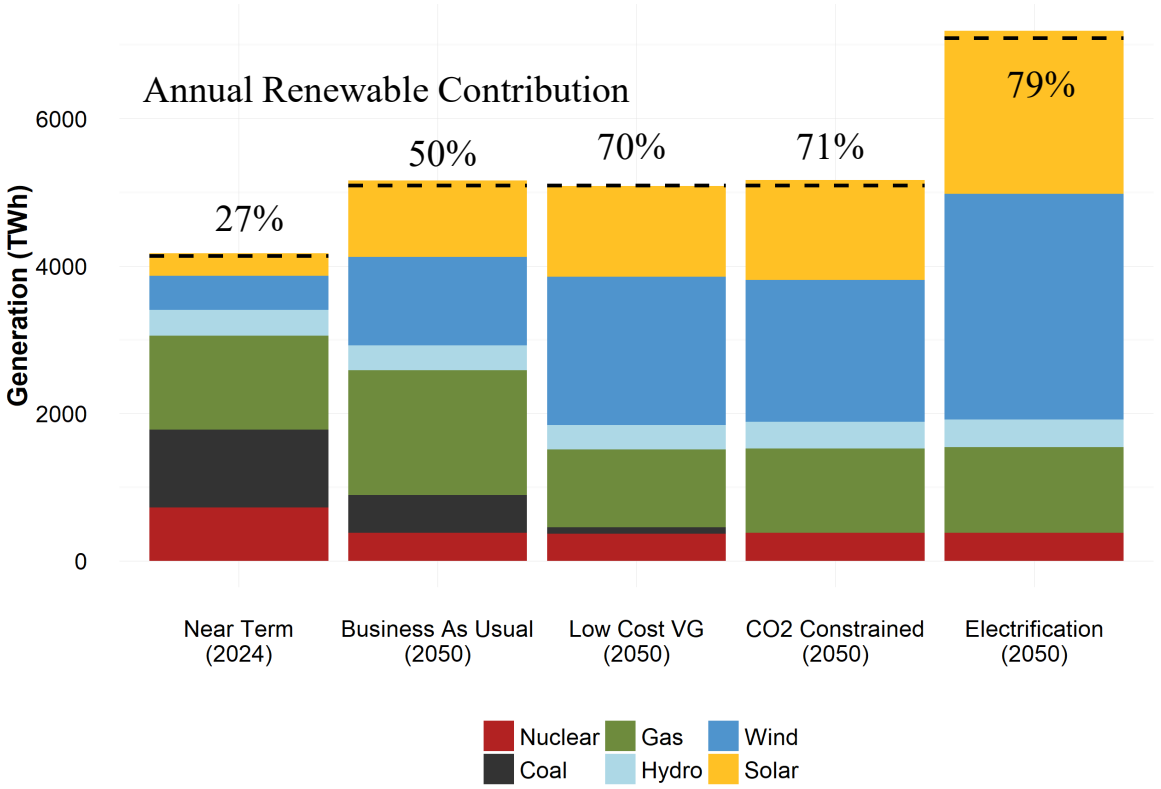
Execution:

- Changes led to significant challenges, but overall scope for Canada and U.S. were completed (to be reported in FY21)
- Primary FY 19 & FY 20 accomplishments included completing all the modeling, analysis, and reporting (data and method development were primarily completed previously)



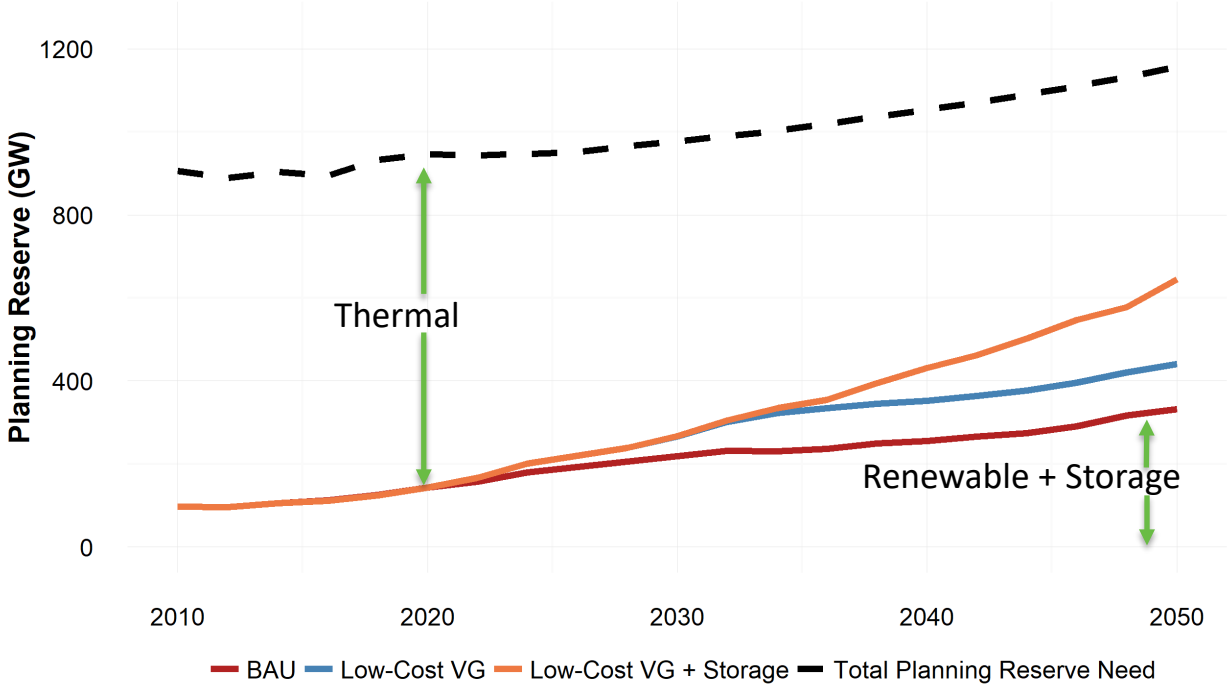
Core Scenarios

- **2050 scenarios:**
  - 50% - 79% Renewable
  - 57% - 84% Carbon-free
- **Low-Cost VG scenario similar to Carbon Constrained**
- **Electrification loads much higher**



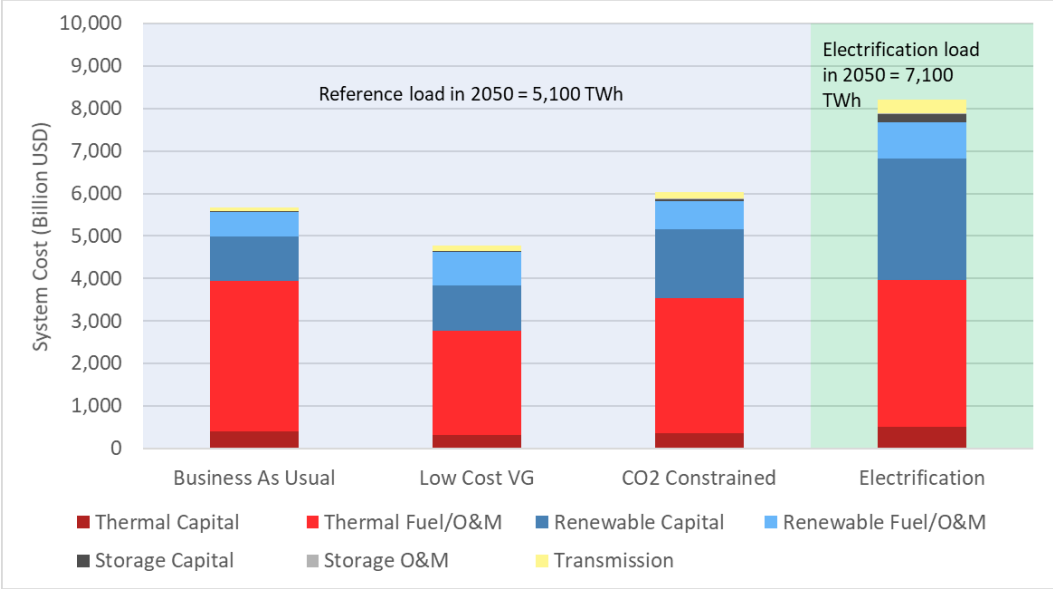
The future low-carbon system can balance supply and demand in a wide range of future conditions; all resource types contribute to this adequacy.

- NERC reliability metrics (LOLH, EUE) similar to or better than 2020 LTRA forecast for 2022
- Increasing peak demand through 2050 served mostly by new renewables
- Over 200 GW of new storage in low-cost storage case ("Low-Cost VG + Storage") displaces thermal planning reserve need



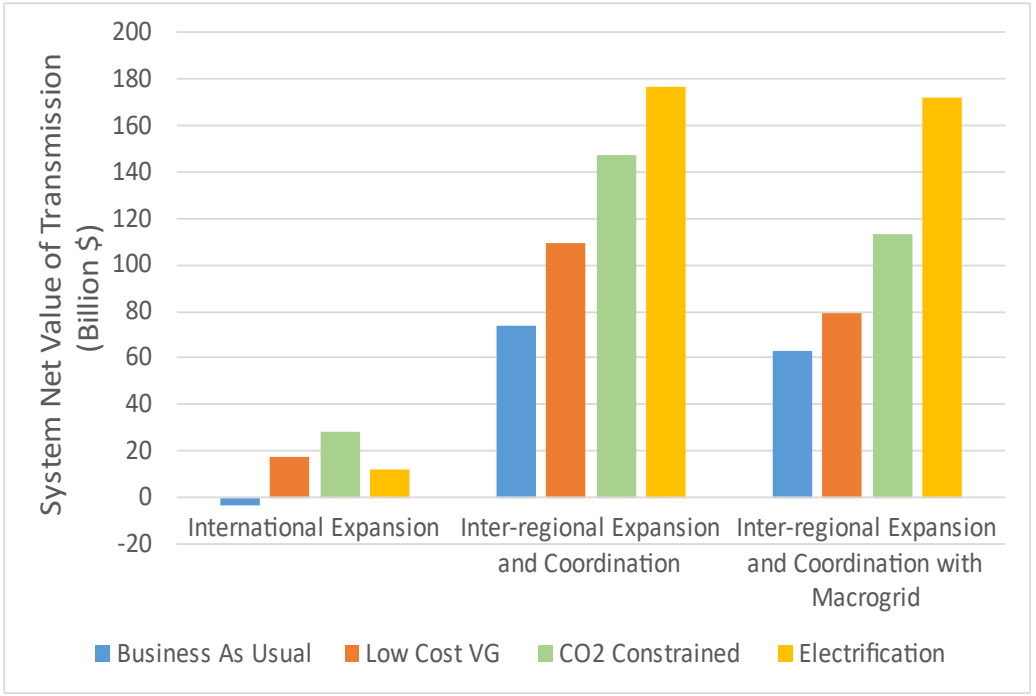
Steeper cost reduction of wind and solar can lead to a cheaper and faster transition

- Carbon targets can still be achieved with conservative wind and solar cost assumptions (for a 6% total system cost increase)
- With low-cost wind and solar, carbon emission reductions come at no additional cost (and 16% lower cost vs. BAU)
- Electrification costs are $2t higher, but don't include non-electric sector cost reductions



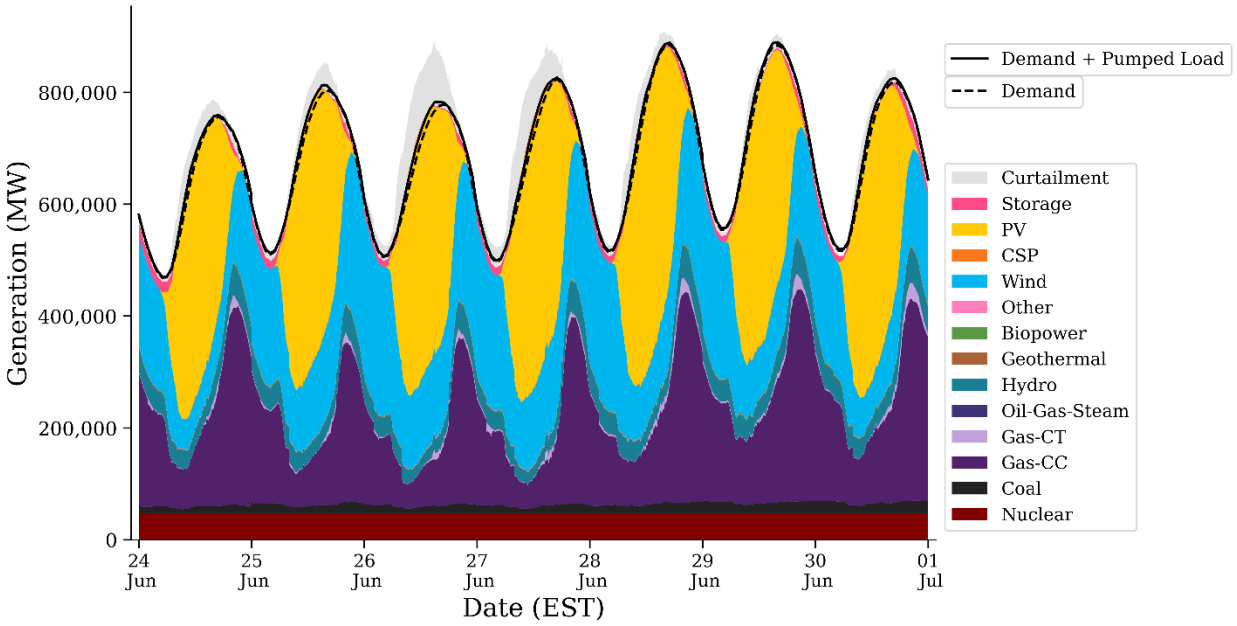
Transmission expansion can provide up to $180b in net benefits to the power system

- International transmission expansion provides $10b - $30b in benefits in high-renewable scenarios
- Inter-regional transmission expansion provides $60b - $180b
- Macrogrid benefits slightly less than the “model optimal” build, there are additional benefits not seen in model (e.g., self-contingency, controllability)



Operational flexibility is provided by all generator types, including hydropower, wind, solar, storage, and thermal generation.

- Ramping of thermal, hydropower, and storage day vs. night
- Transmission enables sharing diversity of renewables between regions
- Curtailment mostly during day (in June)
- Imports from Canada during sunset and sunrise hours



Stakeholder Engagement & Information Sharing

Technical Review Committee (TRC):

- A committee of reviewers from over 40 different system operators and utilities from throughout North America was assembled to review the study methods, assumptions, and conclusions to ensure relevance of the study.

Upcoming Activities: Final edits and publication in late FY21

Methods of dissemination (beyond TRC):

- Reports and executive summaries
- Animations / visualization of dispatch
- Interactive data viewer
- Webinars
- In-person meetings TBD